FINAL PANEL PROJECT REPORT
SIMPLIFIED PRECISION WELDING TECHNIQUE
AGREEMENT # 2019-375-013

March 7, 2025

Project Overview

Two problems with high cost and schedule impact are endemic to ship building and MRO:

- Oversize tack welds that impede robotic and mechanized welding; and
- Plate pits and small scars that are over-welded by legacy methods.

Oversize tack welds are inevitable when shipfitters use the same semi-automatic flux-cored or solid-wire welding processes that are used for production welding. These hand-held methods produce welds that are often larger than the design size for final welding. Higher speed robotic/mechanized equipment makes weld passes over them, increasing the size of the weld and subsequently, cause rework to reduce final weld size – a smaller tack weld is needed. Smaller tack welds must be made quickly and precisely with minimal effort on the part of shipfitters or they will revert to prior used methods. This was proven by two previously funded NSRP efforts to provide automatic tack welders – neither method was implemented because shipfitters did not want to use them.

Corrosion pits and plate scars are encountered everywhere. Again, using legacy welding procedures, shipfitters deposit welds that greatly exceed what is needed for repair. Excess heat input may damage back side coatings, cause distortion, and require significant final correction effort before completion. Pits and scars can occur during ship construction or sustainment. In some cases, these defects may reduce plate design thickness or otherwise not comply with applicable ships specifications and must be repaired. What is needed is the ability to repair corrosion pits and other surface imperfections quickly and efficiently with a system that is easy to use for even lower skilled personnel.

A fast, accurate, efficient, and easily implemented tack welding and repair process already exists in the commercial sector. It can be quickly set up and used to make tack welds or repair individual pits or scars with minimum over welding and minimum time to finish to surface requirements. EWI, in working with the Center for Naval Metalworking (CNM) on a prior ONR ManTech project (ManTech project no. S2831), gained experience with commercial-off-the-shelf (COTS) semi-automatic Gas Tungsten Arc Welding (GTAW) equipment. This COTS device, known as “TigSpeed,” is designed to be able to provide highly mechanized operation that is ideally suited for repair of pits or other damaged sites. The device is in use in the commercial sector for quick and small tack welds in automotive manufacture. A high level comparison of conventional GTAW to semi-automatic GTAW is shown in Figure 1

Category B Data – Government Purpose Rights
Distribution Unlimited/Approved for Public Release.

Semi-Auto GTAW Advantages

- Up to 60% higher deposition rates
- Better seam quality – reduced dilution when weld cladding
- Less weld operator fatigue in not having to manage wire feed
- Increased arc on time enables greater productivity
- "Hot-Wire" capability enables 100% faster travel speed than conventional GTAW
- Controllable weld pool through superimposed forward/backward motion of the wire

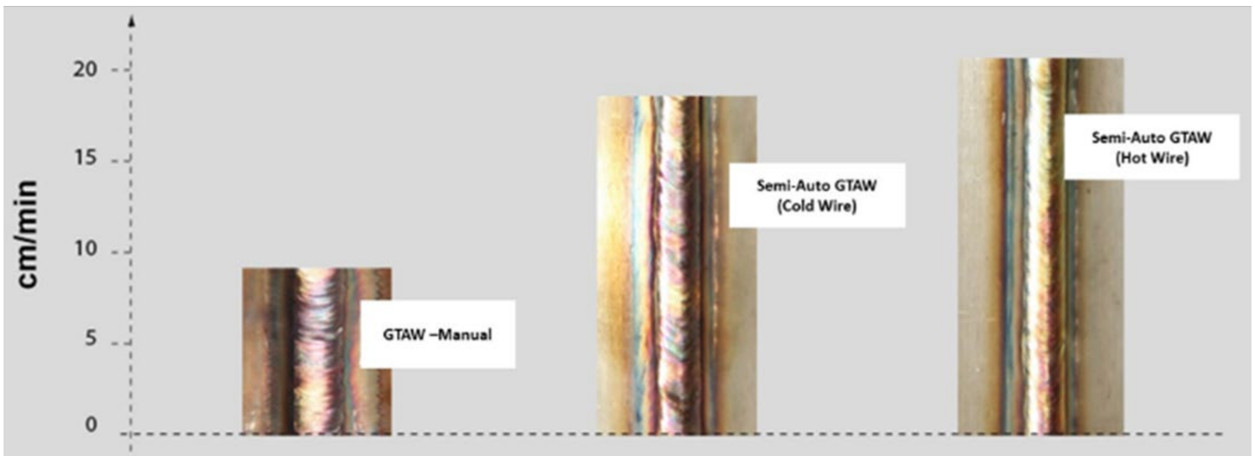

Figure 1. Comparison of Productivity: Manual GTAW vs. Semi-Automatic GTAW

EWI has developed a minimum parameter set for pit repair; procedures for repair of scars can be tailored from experience gained during the S2831 ManTech project.

This project addresses the strategic plan by providing a focused technical solution to these problems, saving time, and increasing quality by quickly making repairs that need little to no post-processing. In many cases, the exquisite control of welding parameters may provide a solution that does not affect the paint on the back side of the metal, providing further savings. Part of the project will address this benefit and provide clear guidance for operators. The project will develop pre-programmed schedules that can be implemented by any welder/filter skill level. Part of the project will address this benefit and provide clear guidance for operators. This COTS equipment is already widely used in the commercial sector, so there are rapid pathways to acquisition and maintenance, if needed. In the S2831 ManTech project, it provided an impressive ROI.

Category B Data – Government Purpose Rights
Distribution Unlimited/Approved for Public Release.

Project Results

This is the Final project report for the subject agreement. Technical efforts for the period of performance (2-21-24 through 3-7-25) include:

Task 1 – Project Initiation and Kickoff

Project team members participated in a kickoff meeting to review project scope and establish current fillet weld tack and corrosion pit and scar repair welding conditions. Inspection requirements for GTAW corrosion repairs were also discussed.

NSWCCD was consulted in follow on conversations to determine a path towards qualification for the semi-automatic GTAW process. Cross section macrographs, microhardness testing, tensile testing, and bend testing were selected as inspection methods for this effort.

Task 2 – Development of Tacking and Corrosion Repair Parameters

This task included developing procedure sets for semi-automatic GTAW pit and scar repair with the TigSpeed equipment in 3 separate welding positions (flat, horizontal, and overhead) to allow for the process to be used throughout the shipyard. Fillet weld tacking procedures were developed in the flat position. Ingalls provided pitted plate material to EWI for parameter development. An overview of TigSpeed equipment is shown in Figure 2.

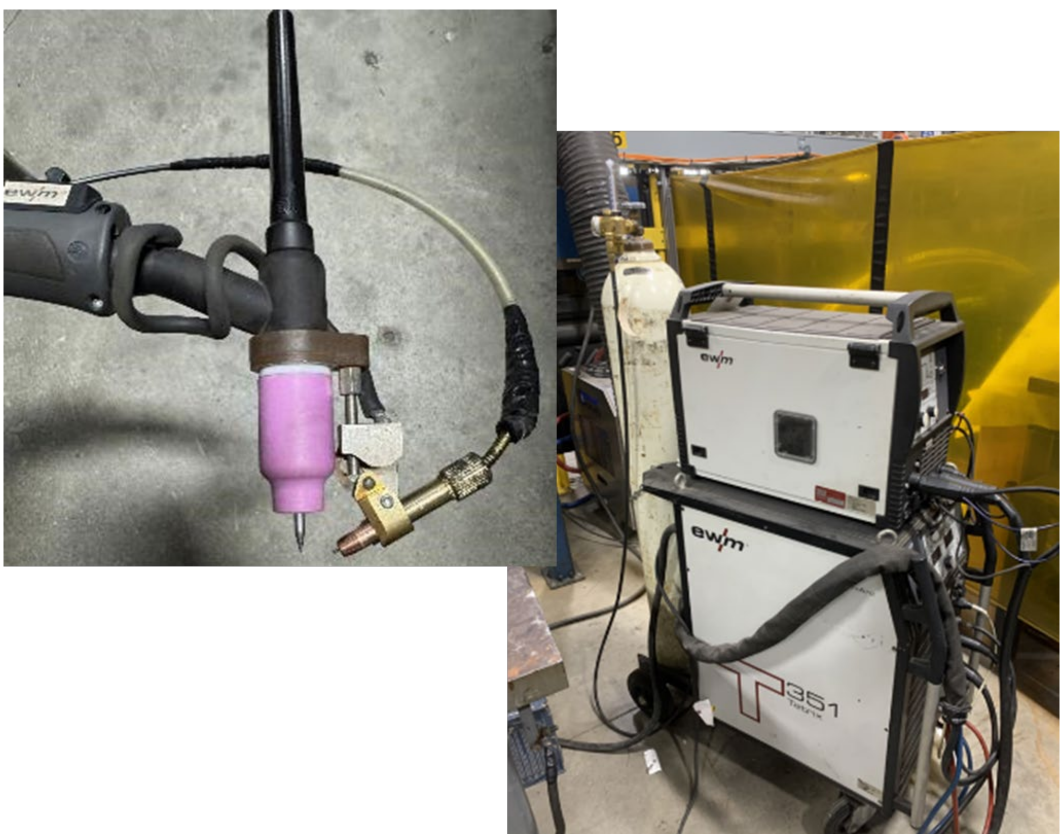

Figure 2. EWM TigSpeed System

Using Ingalls provided pitted plates, TigSpeed weld equipment, and pre-weld cleaning methods agreed upon by the team, EWI developed repair parameters. After successful parameters were made, they were prepared for inspection and testing per the requirements determined by NSWCCD during Task 1. Figure 3 shows the bend test specimen geometry used to test pit repairs.

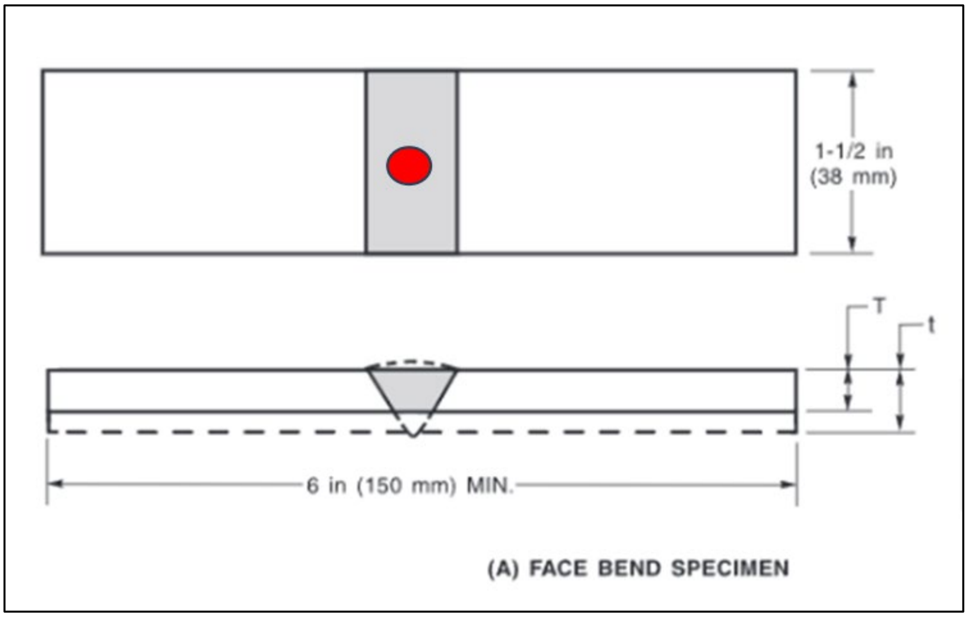

Figure 3. Bend Specimen per AWS B4.0

A heat study was done during flat position repair parameter development, whereby EWI attached thermocouples to the backside of a pitted plate to assess the ability to complete repairs near insulation or painted surfaces without creating a fire hazard. This study yielded a backside temperature maximum of 80.6°F. A photograph of the heat study setup is shown in Figure 4.

Figure 4. Heat Study during Parameter Development

A list of pit repair parameters developed for all positions is shown in Table 1. 2% Lanthanated, 1/8-in. diameter tungsten and 100% Argon shielding gas were used for all positions.

Table 1. Developed Weld Parameters

Position	Amperage	Voltage	Wire Feed Speed (IPM)	Wire Frequency (Hz)	Shielding Gas Flow Rate (cfh)
Flat	161	11.1	39	16	35
Horizontal	161	12.0	39	16	35
Overhead	161	11.6	31	16	35

Hardness testing results for all weld positions is shown in Table 2.

Table 2. Hardness Testing Results

Position	Minimum Hardness (HV)	Maximum Hardness (HV)	Average Hardness (HV)
Flat	198	338	271
Horizontal	182	352	276
Overhead	194	338	261

After verifying the developed parameters were sufficient for pit repairs, EWI welded a NAVSEA Technical Publication 248 qualification demonstration plate, shown in Figure 4.

Figure 5. Tech Pub 248 Qualification Demonstration Plate

Using 1/2-in. thick HSLA 65 and a MIL-STD-22D B1V.1 joint design, the demonstration plate was welded in the vertical position with upward progression. The demonstration plate required 6 weld layers and 11 total passes to complete.

Table 3 lists welding parameters used for the qualification demonstration plate. 2% Lanthanated, 1/8-in. diameter tungsten and 100% Argon shielding gas were used for all weld passes.

Table 3. Demonstration Plate Welding Parameters

Position	Amperage	Voltage	Wire Feed Speed (IPM)	Wire Frequency (Hz)	Shielding Gas Flow Rate (cfh)
Horizontal	161	11.0 – 12.0	31 – 39	16	35

The qualification demonstration plate was inspected by visual (VT), magnetic particle (MT), ultrasonic (UT), and radiographic (RT) testing. All acceptance criteria per MIL-STD-2035A, Class 1 were met.
Two face bends and two root bends were done, both meeting the acceptance criteria of NAVSEA Tech Pub 248. Two transverse tensile tests were done, showing an average ultimate tensile strength of 80,000 psi, meeting acceptance criteria.

A cross section macrograph of the qualification demonstration plate, which met acceptance criteria, is shown in Figure 5.

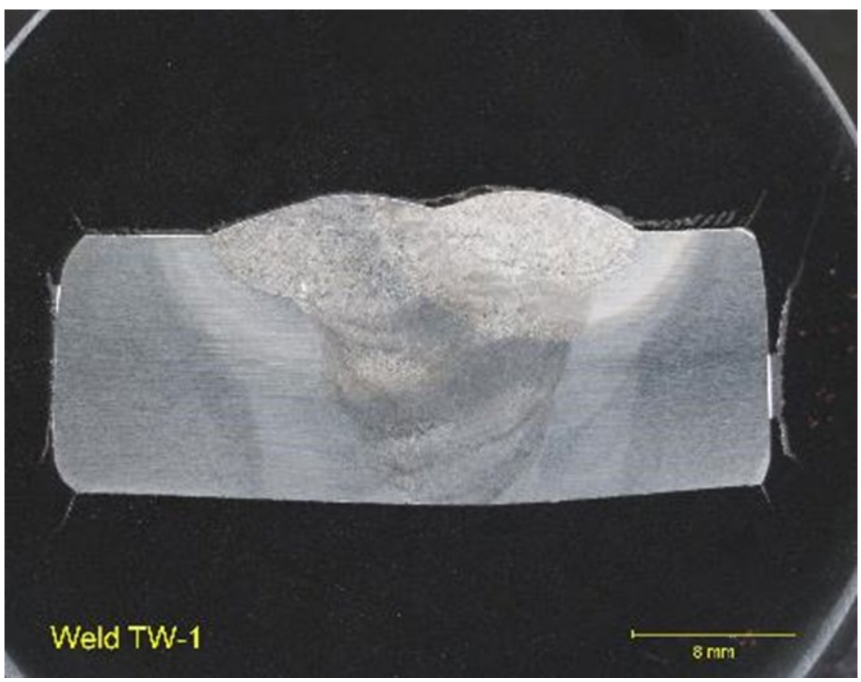

Figure 6. Qualification Demonstration Cross Section Macrograph

Category B Data – Government Purpose Rights
Distribution Unlimited/Approved for Public Release.

Task 3 – Fixture Development for GTAW Torch

The purpose of this task was to develop an apparatus for the semi-automatic GTAW torch that would allow it to be deployed on pit repairs by a less experienced operator. This would allow for the TigSpeed system to operate like a stud welder where a trigger is pulled, the weld arc initiates and terminates, and the welding operation completes with no other input from the operator.

An illustration of the developed GTAW torch fixture is show in Figure 6.

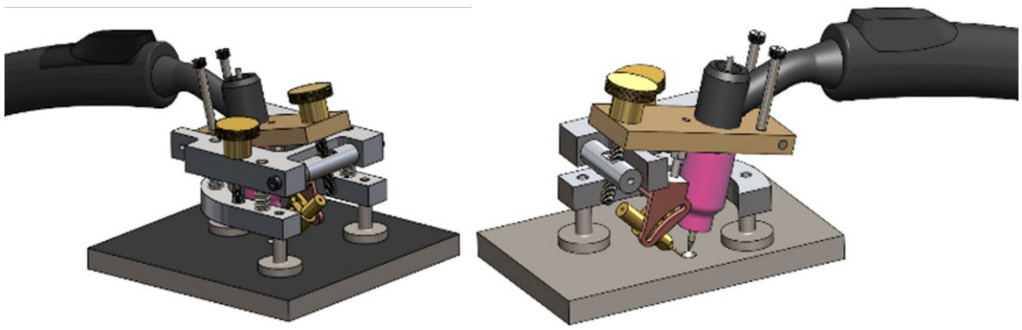

Figure 7. Weld Torch Fixture

The developed torch fixture allows for adjustment of torch standoff and torch angle to account for location and size of a pit repair.

Task 4 – Shipyard Demonstration and Technology Transfer

During Task 4, Ingalls hosted a shipyard demonstration of the pit repair technology at their facility in Pascagoula, MS. This workshop was used to review the results of the project with shipyard participants, identify any additional technology development needs, and plan next steps to drive implementation at the participating shipyards.

Jim Hansen of EWI traveled to Ingalls on February 10, 2025, to prepare the TigSpeed welding equipment and torch fixture within Ingalls' welding laboratory. Working with shipyard staff, Jim prepared a weld cell and several plates for subsequent demonstration to take place the following day.

On February 11, 2025, EWI demonstrated the semi-automatic GTAW pit repair technology on a variety of pitted plates which were provided by Ingalls. Repair procedures were demonstrated for shipyard engineers, technicians, foremen and supervisors. Demonstration participants took turns completing pit repairs with the TigSpeed system, all of whom had never used the system prior to the demonstration. This lack of experience with, yet successful use of the TigSpeed equipment by demonstration participants highlighted the minimal training required to successfully operate the technology.

Upon successful demonstration of pit repair, shipyard participants desired to test the TigSpeed system for welding joints. Fillet welds and butt welds were prepared and welded by participants using the TigSpeed system. These tests were done by using carbon steel and copper nickel weld wire. The shipyard participant desire to test semi-automatic GTAW beyond pit repair demonstrated the ease of use of the TigSpeed system, and that it has potential for other uses within shipyard applications.

Technology Transfer and Implementation

To accommodate for travel to the 2025 NSRP All Panel conference as a technology transfer event, the project period of performance end date was extended from 2/20/25 to 3/7/25. This was a no-cost extension.

All project objectives were completed within the period of performance.

The technology transfer event occurred during the NSRP All Panel conference on 2/25/25, where results from this project were presented.

Conclusion and Recommendations

This project aimed to build off success of previous efforts with the semi-automatic GTAW process and EWM TigSpeed system to further evaluate semi-automatic GTAW as a viable shipyard process. Panel pit repair was the selected application for this effort.

EWI was able to successfully develop pit repair procedures in a variety of weld positions and demonstrate viability of developed parameters through a qualification demonstration test assembly and onsite demonstration at Ingalls Shipyard.

A torch weld fixture was designed, built, and tested as a means of further reducing the impact of operator skill level. Shipyard participant feedback of the process, equipment, and torch fixture were positive.

In this project and previous Navy projects, semi-automatic GTAW has been proven as a viable and efficient weld process that has several potential applications. It is recommended that use of this process on additional applications within the shipbuilding industry be explored.

Category B Data – Government Purpose Rights
Distribution Unlimited/Approved for Public Release.